these sudden squalls which lash into a tempest of waves what is but a mere patch or narrow lane of sea, while all round remains like a sheet of glass, the squall being only the lowermost part of the gyrating column of a slanting whirlwind. Nothing is more surprising to the landsman who encounters one of these squalls for the first time than to see a mere bit of sea lashed into a tempest by say an east wind in which no sail can live, while but a short way to leeward other vessels are seen either under a good-going breeze or in calm water, altogether untouched by the tempest, which seems to blow directly to them, but which strangely never reaches them.

In examining cyclones, phenomena occasionally present themselves which strongly suggest the idea that they include within their circuit, as an independent meteor, the whirlwind or the tornado, the phenomena in question being most frequently met with in those cyclones which present, in close continuity, masses of air differing very widely from each other in temperature and humidity. Of such cyclones the great storm of October 14 last appears to be one. On that occasion the changes of temperature and humidity were sharp and sudden, particularly from the Grampians to the Cheviots, the great fall occurring when the wind changed to northward. As we have already stated (NATURE, vol. xxiv. p. 585), off the Berwickshire coast the darkness accompanying the changes of wind, temperature, and humidity was denser and more threatening than elsewhere, and almost simultaneously with the approach of these changes, a hurricane, or rather tornado, broke out with a devouring energy which bore everything before it. The tornado-character of the storm off Eyemouth is shown by the accounts of some of the survivors, who describe the wind as blowing straight down from the sky with an impetuosity so vehement and overmastering that the sea for some extent was beaten down flat into a stretch of seething foam, in which many boats sank as if driven down beneath the foam by the wind, while outside this tract the waves seemed to be driven up to a height absolutely appalling, which in their turn engulfed many of the boats yet remaining. Similar seas, with level wastes of seething foam, bounded immediately by waves of a height and threatening aspect never before witnessed, were encountered by several well-appointed steamers out in the middle of the North Sea during this storm, thus confirming the observations of the Eyemouth fishermen. These facts seem to point to one or perhaps more tornadoes of no inconsiderable dimensions, with slanting columns, the terrific force of the gyrations of whose lower extremities played no inconspicuous part in the devastation wrought during the continuance of this memorable storm.

(*To be continued.*)

SIR DAVID BREWSTER'S SCIENTIFIC WORK

BUT thirteen years ago there passed away from the roll of living scientific worthies one whose name will ever hold a high place for the variety and scope of the researches carried out with untiring zeal through a long and useful life. Since our last number the centenary of Sir David Brewster's birth has been commemorated in Edinburgh, and the occurrence forms a fitting opportunity to review briefly his multifarious work in the light of the science of to-day. Sir David Brewster was born in 1781. He must therefore have been twenty-five years of age at the date when his first published scientific memoir, entitled "Remarks on Achromatic Eyepieces" (published in *Nicholson's Journal*), saw the light. Until 1867 he continued actively to pursue scientific researches. Whilst his literary works are of themselves amply sufficient to cause the name of Brewster to be handed down to posterity, the long list of four hundred original memoirs which appears in his name in the Royal Society's Catalogue shows with what unremitting ardour the fire of discovery burned within his breast.

In the domain of Physical Optics Brewster was an eager and successful worker: and his industry was rewarded by a series of brilliant experimental discoveries. The genius of Young, the keen perception and quick acumen of Malus, and the trained intellect of Arago had been concentrated on this hitherto neglected department of science. But Brewster, who cannot be said to have possessed, either by birth or education, the powers of any of these investigators, discovered more than all of them put together, and by diligent observation unravelled complicated phenomena which baffled their powers.

In 1812, having heard of Malus's celebrated discovery of the polarisation of light by reflection, he took up the study of polarisation, and in the course of the next two years advanced our knowledge in various directions. He discovered the property of the agate to give a single polarised image; the polarisation of the rainbow; the polarisation tints in thin plates of crystal; the so-called depolarising power of mineral and other substances; and the partial polarisation produced by metals.

These discoveries he followed up immediately by several of equal interest. He observed the double system of elliptical rings of colour in topaz, and subsequently investigated the appearances presented by other crystals, both monaxial and biaxial in convergent polarised light. He not only discovered but determined the law of the partial polarisation effected by transmitting light obliquely through a bundle of thin plates of mica or glass. Meantime he was actively prosecuting literary work. His "New Philosophical Instruments," published in 1813, contained a great deal of matter new in the science of optics, the results of original research. Hitherto in tables of the refractive index of bodies diamond had stood at the head, and ice at the foot of the list. But Brewster showed that realgar and chromate of lead exceed the diamond in refractive power, whilst fluorspar, cyolite, and tabashear fall below ice both in refractive and in dispersive power.

During these and the subsequent years the disturbed relations between Great Britain and France prevented the workers in science on opposite sides of the Channel from learning what progress was being made, with the result that many of Brewster's discoveries were independently made by others. Thus Malus anticipated Brewster in the discovery of the "depolarising" effect of mica films, of the partial polarisation of metals, and of the polarisation effected by bundles of thin plates, though he missed the law of the last phenomenon. Arago also anticipated Brewster in finding the colours of thin crystal plates in polarised light. In 1814 and 1815 Brewster discovered a new relation of polarised light, namely, that existing between the ray and the state of mechanical strain of the body through which it passed. He observed that heated glass exhibited coloured tints in polarised light, and that Rupert's drops did the same. Subsequently he produced both double refraction and chromatic polarisation in soft and indurated jellies, in horn, and in a variety of animal and vegetable bodies, particularly in the crystalline lens of the eyes of animals, whose structure is thereby revealed. The most important of these early researches was undoubtedly the law connecting the angle of maximum polarisation by reflection with the refractive index of the body. The difficulty of establishing such a law was in Brewster's case enhanced by the circumstance that his mind was not a mathematical one. With a skill that rose superior to the defects of apparatus, and with an unflagging patience at which one can only marvel, he scrutinised with minute care every fragment of mineral in the cabinets of his scientific acquaintances. By this means he constructed tables of refractive and dispersive powers and of the polarising angles of the various reflecting surfaces. And from these two sets of data he brought out

the discovery of the tangent law now always identified with his name. But there were other occasions when some mere mathematician stepped in to take up the elaborate facts which Brewster had elaborated, and from them in a few minutes to deduce a law for which he took the credit of discovery. "It seems to us," writes Prof. Tait in an article which appeared in the *Scotsman* shortly after Brewster's decease, "that sufficient allowance has not been made for the natural irritation which such treatment was certain to cause, especially in a high-souled and single-minded man incapable of treating others as he felt himself treated. His biographer will have a painful, but a necessary and salutary, task to perform in gibbeting such thankless parasites. Many a much-praised scientific article—volume even—may be found where the facts are taken mainly from Brewster, though his name is barely mentioned. He was driven by such treatment into frequent disputes about priority, and in general he was successful, though often before the final settlement of the question the obnoxious paper had found its way to a non-scientific public, and even to foreign journals. It is always a difficult matter to determine what is the proper course for a philosopher under such circumstances. Few have the calmness to rely upon the almost invariably just decision of posterity; and most of those who do so go unrecognised to their graves."

In 1816 Brewster announced his discovery of the cause of the colours playing over the surface of mother-of-pearl, and of the possibility of transferring them to casts taken in wax, isinglass, and fusible metals. He also investigated the images and fringes of colour visible in some natural specimens of calc-spar, and turned his attention, though this time with only incomplete results, to the production of tints by multiple reflexions at the surfaces of polished metals. When in 1830 he returned to the subject, there resulted a remarkable memoir on Elliptical Polarisation, which appeared in the *Philosophical Transactions*. In 1817 he discovered the whole class of biaxial crystals, and triumphantly deduced the law of their action on light, thereby solving the difficulties which had perplexed Biot and Arago. He even sketched out a relation between the primitive forms of crystallisation of minerals and their optical behaviour.

His attention was next directed to the question of the absorption of light. In this department of science he made many observations. He was the first to observe in any systematic way the effects of absorption upon the prismatic spectrum. He reinvestigated the solar lines discovered by Wollaston and Fraunhofer, and observed even a larger number of them than the latter had detected. He made the important observation that many of these lines are due to absorption by the earth's atmosphere; and in one of the latest of his contributions to science—a joint paper by himself and Dr. J. Hall Gladstone, which appears in the *Philosophical Transactions* for 1860—he returned to the subject with unabated vigour and unsurpassed perspicacity of thought. He also discovered the power possessed by nitrous oxide gas to produce absorption lines, and he noted the great and extraordinary increase in their number and density when the gas is heated. "The power of heat alone to render a gas which is almost colourless as red as blood, without decomposing it, is in itself a most singular result; and my surprise was greatly increased when I afterwards succeeded in rendering the same pale nitrous gas so absolutely black by heat, that not a ray of the brightest summer sun was capable of penetrating it." Indeed he seemed to be here on the very verge of the discoveries on the spectroscopic significance of the width and frequency of the absorption lines which have been made by Mr. Lockyer, M. Janssen, and others during the present decade. In 1831 Brewster published his "New Analysis of Solar Light," the new analysis being nothing else than the operation of looking at the solar spectrum through coloured absorbent media. It was this series of experiments which led him to conceive the theory of the three primary colours which he so resolutely maintained against all opponents till his dying day. Through his red glass he could see light through a considerable range of the visible spectrum, and therefore, he concluded, there is some red in all parts, but with different degrees of brightness. The yellow and the blue were, he held, also distributed, each with a maximum of its own, throughout the range of the whole light. He believed that he had proved the conversion of blue rays into violet ones by viewing them through an absorbent medium. "We must remember," says Prof. Tait, by way of apology for the persistence with which Brewster clung to his pet theory, "that he trusted to an eyesight that had rarely deceived him—an eyesight once so perfect that he is one of but a very few who have *seen* the extraordinary ultra-red rays which he was the first to discover as visible light."

One of his researches connected the subject of absorption with his work on polarisation. He investigated the property known as *dichroism* possessed by a great number of coloured crystals, tourmaline, Brazilian topaz, and others, a property which has lately given rise to several important investigations by physicists in Germany and in England. He showed how the absorbed tints are altered by heating, and here he anticipated a point in the electromagnetic theory of light which was then of course quite undreamed of.

To enumerate the whole of Brewster's researches would occupy so many columns that only a few of the more prominent must now be adverted to. Optical illusions of sundry kinds, fluid cavities in crystals, polarisation of the sky, phosphorescence, fluorescence, photography, the optical properties of agate, opal, and labradorite, the magic mirror of Japan, and the theory of binocular vision, all claimed their notice and formed the bases of many careful researches. The experimental researches of Brewster in optics are in fact paralleled only by those of Brewster's great contemporary Faraday in electricity.

Brewster was the inventor of several well-known optical instruments. The *kaleidoscope*, which was brought out in 1816, created such a furore that 30,000 were sold in a few days. His *monochromatic* lamp appeared in 1823. In 1849-50 he brought out his lenticular *stereoscope* (an improvement upon Wheatstone's reflecting stereoscope of 1838), and a binocular camera, for use in producing stereoscopic pictures. Still more important, though far less widely known, was his discovery of the application of lenses and combinations of lenses to lighthouses. This was in 1812; in 1820 he was urging the adoption of his system on those in authority—two years before Fresnel, who usually gets the credit of this application, had begun his work.

His objections to the undulatory theory of light endured to the last, when he stood almost alone in his refusing explicit adherence to the theory. Trained himself in another school of thought, and accustomed through long years to the Newtonian theory, it is not remarkable that in the absence of mathematical predilections the mathematical intricacies of the fabric woven by Fresnel had little charm for him. And if we find it hard to realise the slowness of minds like Brewster's to receive the undulatory theory as an established truth, we may perhaps find no inapt parallelism in the repugnance felt even amongst some of the "crowned heads of science" at the present day towards entertaining the still more modern electromagnetic theory of light in which the undulatory theory is fast being swallowed up piecemeal.

Brewster's literary activity was simply extraordinary. He brought out the "Edinburgh Encyclopædia" between the years 1808 and 1830, writing many of the articles himself. To the seventh and eighth editions of the "Encyclopædia Britannica" he contributed the articles on Electricity, Magnetism, Microscope, Optics, Stereo-

scope, and Voltaic Electricity. No fewer than seventy-five articles in the *North British Review* are from his pen. From the year 1819 he was, along with Jameson, editor of the *Edinburgh Philosophical Journal*, in which so many of his researches saw the light. His "Letters on Natural Magic," his "More Worlds than One," his treatise on "Optics," his "Martyrs of Science," and his "Life of Sir Isaac Newton," all testify to an unremitting activity rarely equalled. He was made Principal of the University of St. Andrews in 1838, a post which he relinquished only in 1859 to succeed to the Principalship of the University of Edinburgh. As one of the founders of the British Association in 1831, no less than as a distinguished representative of science, he received the honour of knighthood.

A man who could unite so many varied qualifications in himself, who, besides adding so richly to the total of exact knowledge, could do so much to diffuse that knowledge to succeeding generations, who could write not only with the calm decision of a philosopher, but with the vivid imagination of a poet and even with the fervour of a preacher, must indeed be acknowledged to be a remarkable figure in the age in which he lived. His position in the physical sciences, standing as he did between the old generation of workers and the new, is not very easy to define. But his memory will doubtless descend to posterity in connection with numerous departments of the science of optics, in which his work remains to testify to his place amongst the men of science of whom Great Britain has just reason to be proud.

NOTES

THE Lord President of the Privy Council has appointed Prof. Archibald Geikie, F.R.S., to be Director-General of the Geological Surveys of the United Kingdom, and Director of the Museum of Economic Geology, Jermyn Street, in succession to Sir Andrew C. Ramsay, F.R.S., who retires from the public service towards the end of the present year.

MONDAY night was an enthusiastic Arctic night at the Geographical Society. The first paper was by Mr. C. R. Markham, on the important discoveries made by the *Rodgers* in and around Wrangel Land, and on the proposal that England should lend a hand to search for the missing *Jeannette*, and that a Government expedition should be sent out to look for Leigh Smith. Lieut. Hovgaard of the *Vega* also read an Arctic paper, detailing his plan for a *Jeannette* search from about Cape Chelyuskin as a basis; while an instructive paper was sent by the Dutch Commodore Janssens, on the ice-conditions in Barents Sea, and the probable position of Mr. Leigh Smith in the *Eira*. Of course Mr. Markham's energetic enthusiasm was infectious, and everybody seemed to agree that it would be disgraceful to England not to send out search expeditions. Sir George Nares and Sir Allan Young spoke, but it cannot be said that they threw much light on the problem; the good-natured Sir Allan took much trouble to say he knew nothing about these seas, and therefore he thought an expedition should be sent out for the *Eira*. Mr. Grant, the well-known Arctic photographer, told his experiences on the ice of the Barents with the Dutch and with Mr. Leigh Smith during the last four years, and he seems to think, what every one else thinks, and what is evident, that Mr. Leigh Smith is locked up in the ice somewhere. But all the speakers on Monday night evaded the main point, which was clearly stated in Mr. Eaton's letter in last week's NATURE (p. 123). Mr. Eaton declares that Mr. Smith went out with the deliberate intention of wintering, and that he has now provisions to last two years. Of course, in cases of doubt, it is well to take the worst possible view. But there seems to be a conflict of evidence. Mr. Eaton, than whom no one ought to know better, positively states that the *Eira* is provided as we have indicated; while on the other side there are vague and inconsistent statements. Were we convinced of the real danger of the *Eira's* situation, we should heartily support a relief expedition; but in this case there seems to be no doubt. The matter may be safely left in the hands of the Admiralty, who will doubtless look at the situation all round, and take care that they do not commit themselves, at the most, to more than a mere search, in conjunction, we should suggest, with relatives and friends. But on consideration of all the evidence, it may not be thought sufficient to warrant Government intervention. We were pleased to learn that the object of the Dutch in sending out expeditions year after year to these seas is to obtain a thorough knowledge of the movements of the ice before they venture to send out a fully-equipped expedition to force its way northwards; this is thoroughly scientific in its method.

A BALLOON accident, which we fear may turn out unfortunate, occurred in the South of England last Saturday. Capt. James Templer, Mr. Walter Powell, M.P., and Mr. Agg Gardner, ascended at Bath on Saturday at 1.55 p.m. for the purpose of taking the temperature of the air, and the amount of snow in the air, for the Meteorological Office. Capt. Templer, in a letter to Mr. R. H. Scott, describes what followed: "I cleared the snow clouds at 4000 feet altitude; the temperature of these clouds was 28°, and the wet-bulb thermometer read 26°. At 4200 feet we passed over Wells, the time being 2h. 50m. At this height I worked over Glastonbury; the temperature now rose to 41°, and the sky was perfectly clear. I passed then between Somerton and Langport, and I here found that I was in a N. ½ W. current. I asked Mr. Powell to send the balloon up to 6000 feet to ascertain the temperature of a small bank of cirrus. I found this temperature to be 31°, and then I asked him to place me at 2000 feet altitude, to regain the N. ½ W. current, and we then came in view of Crewkerne. I now kept at a low altitude until I reached Beaminster. Mr. Powell here observed that we were going at thirty miles an hour, and here we first heard the roar of the sea. The balloon suddenly rose to 4000 feet; at this time I said to Mr. Powell, "Go down to within 100 feet of the earth, and ascertain our exact position." We coasted along close to the ground until we reached Symondsbury. I here called to a man and asked him how far the distance was to Bridport, and he said about a mile. I asked Mr. Powell to prepare to 'take in,' our pace now increasing to thirty-five miles an hour. To avoid the little village of Neape Mr. Powell threw out some ballast. This took us to 1500 feet elevation, and we had still two miles to get in. I opened the valve and descended, about 150 yards short of the cliff. The balloon on touching the ground dragged a few feet, and I rolled out of the car with the valve line in my hand. This caused the balloon to ascend about 8 feet, when Mr. Gardner dropped off, and unfortunately broke his leg. I found that the rope was being pulled through my hands, and I called to Mr. Powell, who was standing in the car, to come down the line. He took hold of the line, and in a few more seconds the line was torn through my hands. The balloon rose rapidly. Mr. Powell waved his hands to me, and I took his compass bearings, and found that he was going in a S. ½ E. direction." Capt. Templer lost no time in getting into a steamer at Weymouth and searching the Channel in the most likely direction, but without result. Up to the present nothing has been heard of Mr. Powell, and the worst is to be feared. This accident is certainly to be regretted, more especially as the expedition was in the interests of science. Still in spite of the accident the Meteorological Council are to be congratulated upon the endeavour to get at the correct facts of the air.

IN the *Comptes Rendus* for December 5, 1881, p. 936, there appears a paper animadverting on the meteorological stations it has been proposed to establish in the neighbourhood of the